Testimony of Ginger Goodin
Submitted to the Texas House of Representatives
Transportation Committee
September 18, 2020

Chairman Canales and members—thank you for the opportunity to provide information on Interim Charge 3, which addresses the state policy implications of autonomous and semi-autonomous vehicles regarding their safe use on Texas roadways. I am submitting this testimony in my capacity as a senior research engineer at the Texas A&M Transportation Institute (TTI).

This testimony focuses on relevant information and guidance for the policy discussion, drawing on independent research and current stakeholder engagement activities.

Background

Automated vehicles (AVs)—a combination of technologies and sensors that enable vehicles to operate with limited or no driver input—are rapidly moving from concept to real-world application. AVs hold the promise to improve safety by reducing crashes due to human error and offer mobility options for people with disabilities. Low-level or semi-automated AV technologies are already available on new vehicles today, and high-level or fully automated AVs are projected on a 10- to 15-year horizon. On-road vehicle testing is under way on public roads today. Vehicles that are increasingly automated and connected have the potential to change personal, freight, and public transportation profoundly. Some impacts can be foreseen, others are uncertain, and all are complex.

While the technological advancement is impressive, many unknowns surround the widespread deployment of AVs. For AVs to safely and optimally function, the transportation infrastructure may need to change or be maintained at a higher level than the current standards require. These changes could result in significant costs for state and local governments. Meanwhile, publicly funded agencies are already stretching limited resources to meet the ever-growing demands on today's transportation system.

Despite uncertainty, the transformational nature of AV technology dictates a need for consideration by government agencies about possible outcomes that can effectively manage public interest and societal concerns. However, operating in a state of constant change and high uncertainty creates many challenges for establishing a firm regulatory or legislative foundation.

Texas Department of Transportation Connected and Autonomous Vehicle Task Force

The most important resource for future AV policy development in Texas is a Connected and Autonomous Vehicle (CAV) Task Force. The Texas Department of Transportation (TxDOT) established this task force under direction of the Office of the Governor, with the goal to be a single point of information and coordination for CAV advancement in Texas. The CAV Task Force is hosting industry meetings, creating a knowledge base for best practices and collaboration, and reporting on lessons learned. The CAV Task Force is also serving as a clearinghouse of information for those seeking to pursue innovative technology in Texas, and as an incubation hub for any policy recommendations to the Texas Legislature and governor.

The scope of the CAV Task Force encompasses key policy issues and intends to provide policy makers with informed guidance drawn from the experience and expertise of multiple public and private stakeholders.

TTI is providing technical support to the Texas CAV Task Force in a variety of efforts, including:

- Coordination of the full task force membership functions and its subcommittee meetings.
- Development of topical white papers.
- Delivery of an external website.

Members of the CAV Task Force and other industry partners have established five subcommittees addressing specific topics related to CAV:

1. Education, Communication, and User Needs.
2. Freight Delivery.
3. Licensing and Registration.
4. Data, Connectivity, Cybersecurity, and Privacy.
5. Safety and Liability.

Currently, TTI is supporting TxDOT and these CAV subcommittees by developing white papers for delivery to the CAV Task Force and Texas Legislature on the following topics, which speak directly to the interim charge:

- Terminology related to CAVs.
- Public outreach.
- Roles and responsibilities related to CAVs in Texas.
- Infrastructure issues and needs.
- Education, awareness, levels, capabilities, and registration.
- Safety use cases.

TTI and its university partners are engaged in leading-edge research across multiple related areas and are drawing upon a wide range of interdisciplinary subject matter experts who can support the white papers currently under development. The white papers should be completed before the upcoming legislative session begins.

Related Research

TTI is engaged in numerous research studies related to AVs, including those associated with traffic operations, human factors, consumer acceptance, transportation planning, applications of connected car data, freight automation, transit automation, low-speed shuttle operation, and interaction with vulnerable road users.

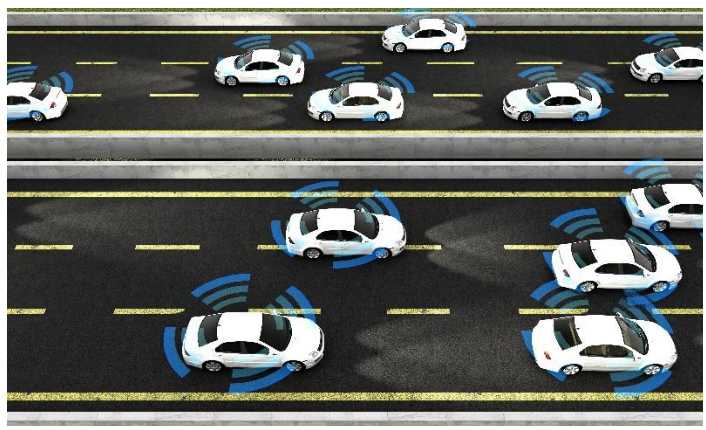
The remainder of this testimony highlights four key research areas associated with one specific topic of interest: **infrastructure support and readiness**. The four areas are:

- Connectivity.
- Pavement wear.
- Pavement markings.
- Dedicated lanes.

To prepare for the future of AVs, infrastructure operators and the public are interested in roadway features that will be needed for optimizing performance of AV safety systems, as well as the overall safety and mobility performance of the roadway infrastructure.

Connectivity

The most significant gains in safety and mobility performance will occur at the nexus of AVs and connected vehicles (CVs). In contrast to an AV, which is designed to operate independently of the actions of surrounding road users, a CV has internal devices that virtually connect it to other vehicles (vehicle-to-vehicle [V2V] communication) or to a back-end infrastructure system (vehicle-to-infrastructure [V2I] communication). V2I applications enable mobility, congestion mitigation, and environmental benefits more effectively than what can be provided by AVs operating independently.



At present, V2V and V2I applications solely provide driver alerts; they do not control the operation of the vehicle. In coordination with AV technology, however, connectivity could increase situational awareness for AVs, including navigating challenging "edge cases" (e.g., construction work zones or blind curves) and supporting coordinated flow of vehicles.

In terms of vehicles communicating with the infrastructure, two technologies are competing to be the near-term solution. On one side is dedicated short-range communications (DSRC), which is a short-range wireless communications technology operating in the 5.9-gigahertz spectrum. On the other side is cellular V2X (C-V2X), a hybrid technology that can be thought of as having two radios operating in tandem—one to communicate with the cellular cloud and the other to communicate on a direct link with nearby objects, such as other cars or infrastructure. Both technologies will likely be surpassed by 5G as the ultimate connectivity solution, but this would appear to be at least a decade away.

Why is spectrum technology important? Without a federal directive clarifying spectrum, it is difficult for manufacturers to know what radio equipment to install in their new vehicles and for infrastructure operators to know what equipment to implement on the roadside. Manufacturers have indicated competing preferences for future models of vehicles.[1,2] And to overcome the uncertainty, some transportation agencies that are testing CV use cases are experimenting with dual-mode readers on the roadside to be able to read both DSRC and C-V2X signals from test vehicles.

The market penetration of equipped vehicles will grow over the next 10 to 20 years. In the meantime, numerous CV-related research activities are under way at TTI to test and evaluate applications of CVs for improving safety, mobility, and eco-driving, including the following:

- *Smart intersections*—Using TTI's Smart Intersection testbed at Texas A&M's RELLIS campus, researchers are creating solutions to improve communication between CVs and traffic signals, including development of national standards to reduce red-light running and applications to promote eco-driving that reduce stops at signals.
- *Wrong-way driving*—Researchers are developing solutions to detect and mitigate dangerous, high-speed, wrong-way vehicles by improving emergency notification and alerting nearby drivers through CV technologies.

Pavement Wear

Most AVs are programmed to follow a set path and maintain a lateral position in the center of the lane. It is expected that over time, this will create significant pavement rutting. TTI's research has investigated the lateral wandering patterns of AVs and human-driven vehicles. The research determined that AV lateral wandering is at least three times smaller than the wandering of human-driven vehicles. Pavement-wear modeling has shown that AVs with smaller lateral wandering would shorten pavement fatigue life by 22 percent and increase pavement rut depth by 30 percent,[3] which leads to a much higher risk of hydroplaning (see Figure 1). To reduce the negative impact of AVs on roadway safety and pavement life, this research recommends an optimal AV wandering pattern that will result in prolonged pavement life and decreased hydroplaning.

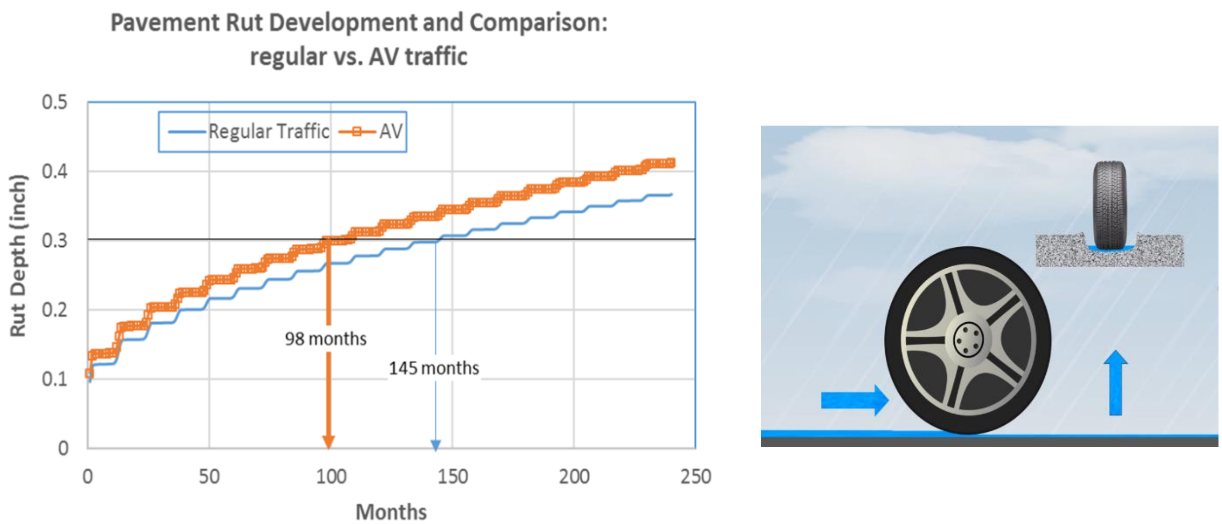


Figure 1. Pavement Rutting and Hydroplaning.

Recent research by TTI for TxDOT[4] on truck automation and platooning shows similar results. For a variety of different measures of distress, automated trucks are expected to create a measurable impact on average pavement service life. The research identified two possible pavement-hardening solutions: building dedicated truck lanes and hardening paved surfaces using polymer-modified asphalt.

Pavement Markings

TTI has been a national leader in conducting research that identifies the pavement marking characteristics most important for roadways in general, and now for vehicle sensor systems. While development of machine vision systems is constantly advancing, a 2018 report[5] identified the following contributing characteristics for detection of pavement markings:

- Contrast between the marking and road surface, both daytime and nighttime.
- Pavement marking width.
- Wet-weather characteristics.
- Lane line pattern (broken versus solid, and length of line and gap).
- Marking texture.
- Nighttime reflectivity of marking.

TTI research identified the high-performance contrast requirements and concluded that the vehicle camera sees pavement markings similarly to a human, which indicates that good pavement marking practices for a human driver will provide good visibility for vehicle machine vision systems.

TTI is now developing a benchmark for evaluating different lane markings and machine vision perception algorithms.[6] The work builds on earlier research with the intent to create suitable standards for pavement markings that enable reliable functionality of the vehicle's sensor system. The reference benchmark will be used to evaluate current markings and create a specification for installation of new lane markings that support AVs.

Dedicated Lanes

Creating dedicated lanes for AVs is mentioned frequently as a way to accelerate AV deployment and achieve performance benefits. The notion of separating AVs into dedicated lanes to reduce risk and gain efficiencies is not without many technical, public acceptance, and equity complications. The following considerations are drawn from a growing body of research[7] and Texas's long history of dedicated lanes to manage congestion, via high-occupancy vehicle lanes and express toll/managed lanes:

- Dedicating pavement space to one particular set of users carries risk associated with limiting access for other users. Therefore, a clear policy that supports the purpose of lanes and performance objectives is a best practice. Is the goal to achieve greater vehicle throughput or greater person throughput? What are the safety and mobility tradeoffs? What behavior is being incentivized?
- The impacts to other road users may depend on how the policy is implemented. Is the intent to allow AVs in existing dedicated lanes, build new dedicated lanes, or repurpose existing lanes?
- The range of differences in roadway geometry plays a role in effective application, such as access/egress features, presence of a physical barrier between the dedicated lane and general lanes, lane width, and the number of lanes.
- What is the enforcement intensity that restricts unallowable categories of users to enter the dedicated lanes? What about toll collection enforcement if a fee is required? Can users be compelled to comply with dynamic operations, such as changing hours of operations?
- High-level AVs without connectivity have the potential to actually degrade highway throughput and traffic flow stability, whereas low-level, semi-autonomous vehicles using cooperative

adaptive cruise control (CACC) could significantly improve these performance measures, depending on how their headways are set.

- From a policy perspective, a criterion for dedicated lane access could be the use of V2V connectivity because the concentration of CVs in the lane is the fundamental way of gaining benefits. For example, vehicles without any automation but with V2V communication capability can serve as the leaders for CACC-equipped follower vehicles, helping to accelerate the benefits.
- At the current state of AV development, with different levels of AV sophistication by vehicle developers, it may be impractical to specify a single dedicated-lane AV readiness requirement suitable for all users.

Dedicated freeway truck lanes may be the first to accommodate AVs separate from other vehicles. TTI is a member of a team that is coordinating environmental clearance and concept development for the Georgia Department of Transportation's (GDOT's) I-75 Commercial Vehicle Lanes facility. This is one of GDOT's Major Mobility Investment Program projects, a 40-mile, two-lane, northbound truck-only facility to separate trucks from automobiles for congestion relief and safety, between the I-75 and I-16 interchange north of Macon to McDonough (just south of Atlanta). TTI is advising GDOT on how to develop this first-of-its-kind commercial vehicle lanes facility in a way that accommodates connected and automated truck technologies expected to be online by the facility's opening date in 2028.

Thank you for the opportunity to provide this committee with information from TTI. Please contact me if you require any further information.

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1 Ford has announced that it will be introducing C-V2X communications in all new vehicles beginning in 2022: K. Musulin, "Ford to deploy C-V2X tech in all new vehicles in 2022," Jan. 7, 2019, https://www.smartcitiesdive.com/news/ford-cv2x-tech-new-vehicles-2022/545412/. C-V2X has garnered significant attention from other automakers like BMW and Tesla.

2 C. Dawson, "GM and Toyota back DSRC to link connected cars to 'smart' traffic lights; Ford, BMW, other auto makers favor '5G,'" May 7, 2018, https://techblog.comsoc.org/2018/05/07/gm-and-toyota-back-dsrc-to-link-connected-cars-to-smart-traffic-lights-ford-bmw-other-auto-makers-favor-5g/.

3 SAFE-D UTC, *Pavement Perspective on AV Safety through Optimizing Lateral Positioning Pattern*, 2018, https://safed.vtti.vt.edu/projects/pavement-perspective-on-av-safety-through-optimizing-lateral-positioning-pattern/

4 Evaluate Potential Impacts, Benefits, Impediments and Solutions of Automated Trucks and Truck Platooning on Texas Highway Infrastructure, TxDOT Research Project 0-6984, 2020.

5 A. Pike and T. Barrette, *Evaluation of the Effects of Pavement Marking Characteristics on Detectability by ADAS Machine Vision*, NCHRP Project 20-106(06), May 2018, http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-102-06finalreport.pdf.

6 Reference Machine Vision for ADAS Functions, in progress research sponsored by Safe-D UTC, completion December 2020.

7 National Cooperative Highway Research Program, *Dedicating Lanes for Priority or Exclusive Use by Connected and Automated Vehicles*, NCHRP Report 891, Transportation Research Board, 2018, https://www.nap.edu/download/25366.